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A NEW MEASUREMENT OF THE PACKING FRACTIONS OF THE NICKEL ISOTOPES

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INTRODUCTION

The most recent determination of the packing fractions of the nickel isotopes was reported¹ in 1941. The source of positive ions for this measurement was a high voltage discharge through a vapor mixture of $\text{Ni}(\text{CO})_4$ and $n\text{-C}_7\text{H}_{16}$. No further details were given on the source but in a previous paper,² it was suggested that the cylindrical discharge tube was provided with an aluminum bar anode and a concave iron cathode. In the absence of more details it is difficult to judge the constancy or reproducibility of this source of positive ions. Generally speaking, a high voltage gaseous discharge tends to produce an intermittent and fluctuating beam of ions. In view of the uncertainties of this type of source and the rather surprisingly rapid and irregular variation in the binding energy of the nickel isotopes, as inferred from the packing fraction measurements of the authors,¹ it was deemed desirable to make new measurements under completely different conditions.

SOURCE

The positive ions of nickel were derived from a new ion source,³ the schematic representation of which is shown in Figure 1. The tungsten crucible, which holds the metal to be vaporized, was made by drilling a hole 2.5 mm diameter, and 5 mm deep in a pure tungsten rod 5 mm diameter and 9.5 mm long. A flat spot was ground on the opposite end of this tungsten rod and a one mm support rod of pure tungsten spot welded to this spot. The material to be vaporized was introduced into the crucible after which a tight fitting, pure tungsten cap was placed over the hole in the crucible. This cap was provided with an axial hole 0.25 mm diameter which limited the cross section of the beam of emerging vapor.

The crucible thus prepared was supported in the axis of a pure tungsten filament in the form of a circular loop. The filament was made of wire 0.425 mm diameter and operated at approximately 15 amperes. The plane of this filament was located 1.5 mm back from the plane of the tungsten cap. In this way electrons from the filament performed the double function of vaporizing the material within the crucible and ionizing it as it emerged through the hole in the cap. It is of interest to observe that this source produces spectra as high as the eighth order when the bombarding voltage is approximately 600.

The thermal radiation given off by the hot crucible upsets the equilibrium of the filament by raising its temperature beyond the point corresponding to the power dissipated in it. Although the filament power may be controlled manually, for the best stability and reproducibility it is desirable to employ electronic regulating and stabilizing circuits. These are shown in block diagram in Figure 1. Complete details of these circuits and the source will be published elsewhere.

The supply voltages for the source enter through 30 kv isolation transformers since the source proper is above ground by the magnitude of the accelerating voltage. The coarse controls are provided by the variacs shown, whereas the fine controls are attached to the individual emission

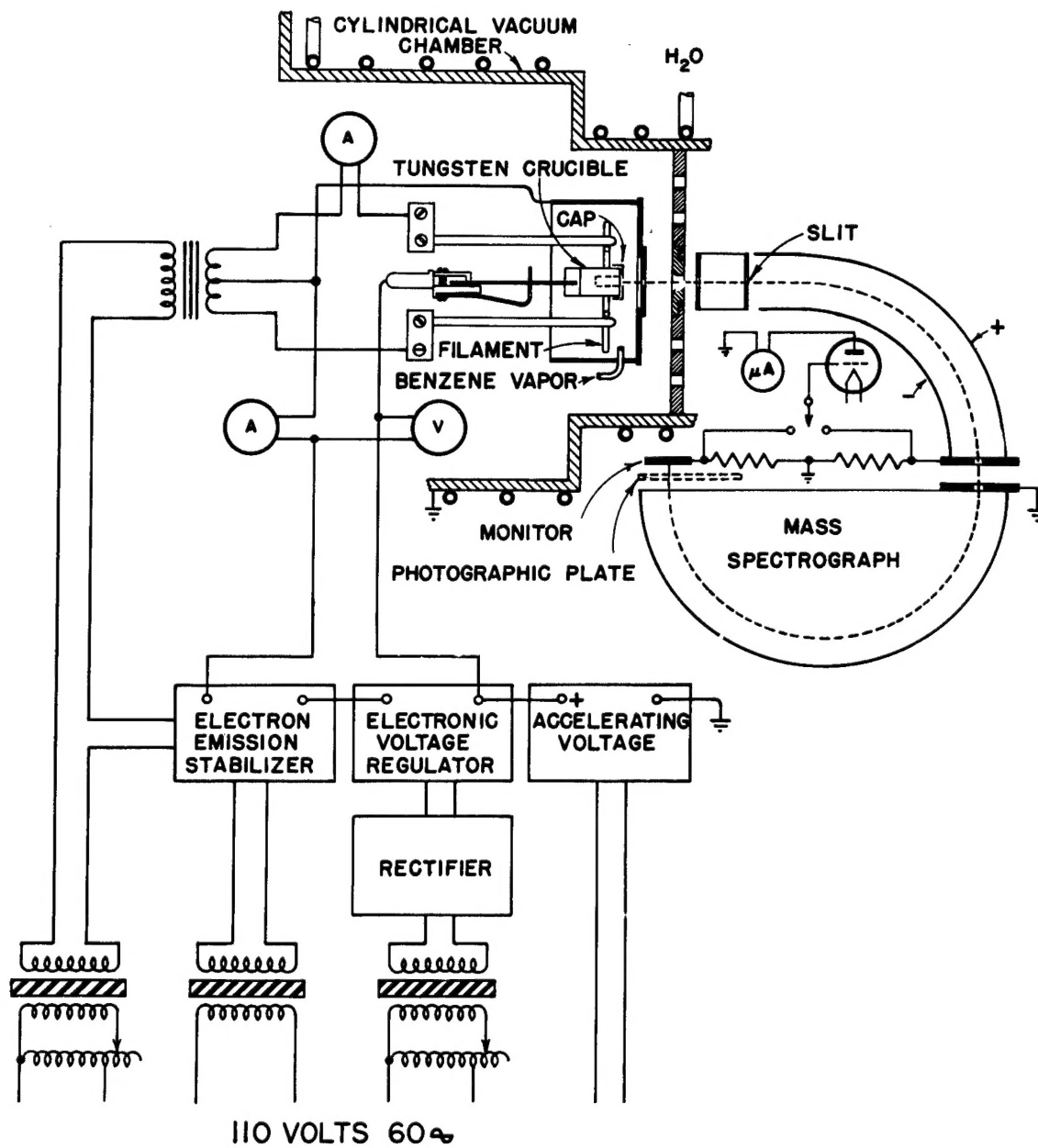


Figure 1.

stabilizer and voltage regulator. The product of the electron current to the crucible and the bombarding voltage is taken as a measure of the power dissipated in the crucible. This is only approximate but it serves as a convenient means for reproducing a fixed set of conditions.

EXPERIMENTS

In order to utilize this source for packing fraction measurements of nickel, it was necessary to provide a standard hydrocarbon comparison line for each of the nickel isotope lines. This was accomplished by introducing benzene vapor directly into the ionization chamber through a small tantalum tube. (See Figure 1.) Thus both the nickel vapor from the hot crucible and the benzene vapor were ionized simultaneously by the same 600 volt electrons. The hydrocarbon lines were sufficiently intense with pressure of the order of 5×10^{-5} mm Hg. The nickel lines were brought out with comparable intensity by 30 watts of electron power dissipated in the crucible. The photographs were made with a double-focussing Mass Spectrograph,⁴ in which the principal slit was set at 0.020 mm. Exposure times varied from three minutes to five minutes. The monitor shown in Figure 1 provided a check of the intensity and constancy of the ion beam. When desired, the photographic plate is moved into the path of the beam by means of an externally controlled Wilson Seal.

RESULTS

Second order spectra were photographed to obtain a comparison line for ^{58}Ni , since no line corresponding to $m/e = 58$ has been observed with benzene. First order spectra contained the four doublets which were used for the measurements of ^{60}Ni , ^{61}Ni , ^{62}Ni , and ^{64}Ni . The hydrocarbon comparison line for ^{64}Ni was the ^{13}C isotope peak.⁵ In Figure 2 is shown a photographic enlargement of a typical triplet from which the doublet $^{58}\text{Ni}+2 - ^{12}\text{C}_2\text{H}_5$ was obtained. Figure 2 also shows the four doublets in the first order.

All measurements of doublet separation were made on a Gaertner Comparator whose scale read directly in thousandths of a millimeter. Each final value of doublet separation was the result of five separate measurements that were generally reproducible to within ± 0.002 mm. All measured values were given equal weight and expressed in terms of the probable error in the arithmetic mean. The table below gives a summary of the data.

Doublet	Number of doublets	$F_2 - F_1$	$F_1 \times 10^4$
$^{58}\text{Ni}+2 - ^{12}\text{C}_2\text{H}_5$	7	24.9631	-8.29 ± 0.07
$^{60}\text{Ni} - ^{12}\text{C}_5$	10	11.9033	-8.69 ± 0.08
$^{61}\text{Ni} - ^{12}\text{C}_5\text{H}$	9	13.2431	-8.75 ± 0.08
$^{62}\text{Ni} - ^{12}\text{C}_5\text{H}_2$	10	14.7416	-9.01 ± 0.05
$^{64}\text{Ni} - ^{12}\text{C}_4^{13}\text{CH}_3$	7	16.0200	-8.62 ± 0.08

Note: The masses of ^{12}C and H used in the calculations of F_2 were values recommended by Bainbridge, Isotopic Weights of the Fundamental Isotopes, Preliminary Report No. 1, National Research Council, June 1948 p. 19. The mass of ^{13}C was that given by Flügge - Mattauch Phys. Zeit. 44:192 (1943).

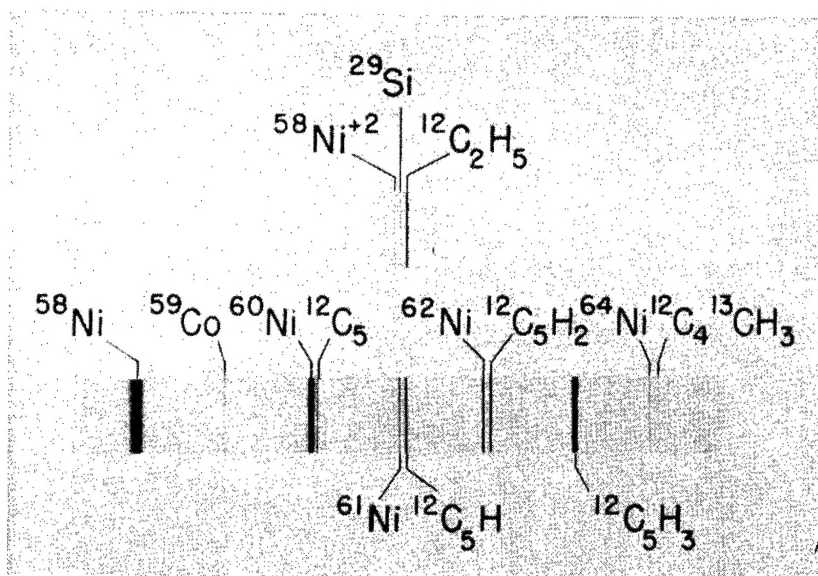


Figure 2.

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